

Lorenz and Swenson (1951) indicate that (at the time of their study) the outer edges of the valley had the highest water-level altitudes in June as a result of spring runoff. Since their report was prepared, the hydrologic regimen has changed because irrigation in the valley has increased and a system of drains has been dug by the U.S. Bureau of Reclamation.

Ground water is discharged by evapotranspiration and by flow into the lower reaches of Prickly Pear, Tenmile, and Silver Creeks, a system of drainage ditches, and Lake Helena directly. Withdrawals from wells constitute a relatively small, but important, part of groundwater discharge.

Well construction

Two types of well construction predominate in the Helena valley. The first type is a drilled or driven well which is 2 to 8 inches in diameter and is cased with metal. Most casings are open only at the bottom of the casing but some are perforated. The second type is a hand- or machine-dug well cased with wood, brick, cement, or metal. Dug wells, generally, are shallow, open only at the bottom, and 2 to 4 feet in diameter. Some wells are a combination; a dug well which has been deepened by drilling or driving a smaller diameter casing inside the old well. Wells are used mainly to supply stock, domestic, and irrigation water. Dug wells generally have smaller yields than deeper drilled wells, but supply enough water for domestic- and stock-supply purposes.

Collection and handling of water samples

Three suites of samples were collected. The first suite of water samples was collected to determine the general character of the ground water. This suite of 20 samples was analyzed for the more common inorganic constituents and detergent (Methylene Blue Active Substance, MBAS). Included were 18 samples collected from wells and a sample from Lake Helena and one from the Helena Valley Regulating Reservoir (table 2). The second suite of samples was collected to determine the effect of septic-tank effluent on the ground water. The second suite included 69 samples analyzed for constituents indicative of man's activities (table 3) and 65 samples analyzed for the presence of coliform bacteria. The third suite of 10 samples was collected to determine the effect of industrial processes on the ground water. This suite of 10 samples was analyzed for selected trace elements (table 4).

All analyses tabulated herein were done at the U.S. Geological Survey laboratory in Salt Lake City, Utah. Most samples for bacteriological analyses cited were analyzed at the Montana Department of Health Laboratory in Helena. Five bacteriological analyses were made in the U.S. Geological Survey laboratory in Helena.

Different chemical constituents require different treatment to prevent deterioration before analysis in the laboratory. Several samples were collected at each site. A complete set of samples included four samples--one of untreated water, one of water filtered through a 0.45 micrometer membrane, one of water filtered and acidified so as to lower the pH to about 3 by the addition of double-distilled reagent-grade nitric acid, and one of water filtered and treated with mercuric chloride. Immediately after collection and treatment, the samples were chilled to about 4°C and airmailed in a refrigerated chest to the laboratory in Salt Lake City for analysis.

Samples for bacteriological analysis were collected in sterile bottles after the collection points had been disinfected by heat from a blow torch. These samples were taken to the laboratories in Helena where the analyses were begun within 4 hours.

Quality of ground water

General character of the ground water

The results of the analyses for common-found inorganic constituents (table 2) show the ground water to be a calcium bicarbonate type with the exceptions of samples from wells 10N3W16dca and 10N4W15dbb. Total hardness ranged from 100 to 520 mg/l (milligrams per liter) and averaged 229 mg/l; the water in general is considered "hard". Samples from wells 10N4W5dbb and 11N4W13dd had a dissolved-solids content greater than 500 mg/l and the average of the 18 well samples was 354 mg/l dissolved solids. Sample 10N4W15dbb, which had the highest dissolved-solids content and total hardness, 889 mg/l and 520 mg/l respectively, was a mixed ion type. The well sampled is near the edge of the study area and the constituents in the water are probably derived from a local source. Sample 10N3W16dca had an anomalously high sodium chloride content and low calcium content.

Samples from wells 10N4W23bab, 11N3W21dcc, and 11N3W30dad, and the sample from Lake Helena had iron and manganese concentrations higher than recommended limits for potable supplies. The objection to iron and manganese in excess of established limits is mainly esthetic and economic. Higher concentrations may produce reddish or brownish stains and impair the taste of the water. A possible source of metals in ground water from wells in 11N3W21dcc and 11N3W30dad and in water from Lake Helena is drainage from the Scratch-gravel Hills, where iron and manganese oxides are common in the rocks. Another possible source throughout the aquifer is solution of iron and manganese oxides that have formed coatings on the gravel and boulders in the basin-fill deposits. All other constituents analyzed were less than the limits recommended for drinking water.

Table 2.--Chemical analyses of water samples from 18 wells and two reservoirs

(Concentrations in milligrams per liter except as indicated)

Location	Depth of well or elevation of reservoir (feet)	Date of collection	Silica (SiO ₂), dissolved	Iron (Fe), dissolved (ug/l) ^{1/}	Manganese (Mn), dissolved (ug/l) ^{1/}	Calcium (Ca), dissolved	Magnesium (Mg), dissolved	Sodium (Na), dissolved	Potassium (K), dissolved	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Alkalinity, total (as CaCO ₃)	Sulfate (SO ₄) dissolved
Wells													
1ON3W3cab	44	8-17-71	27	10	10	48	12	15	3.2	175	0	144	64
1ON3W5aba	42	8-17-71	23	10	< 1	61	12	18	2.9	217	0	178	45
1ON3W6acd	48	8-18-71	22	10	< 1	62	15	21	3.1	241	0	198	58
1ON3W7abb	42	8-18-71	22	10	< 1	58	15	21	3.0	244	0	200	53
1ON3W11dbd	60	8-16-71	21	10	10	48	10	15	3.2	164	0	135	57
1ON3W15bad	79	8-17-71	22	10	10	35	8.0	15	2.8	124	0	102	56
1ON3W16dca	60	8-17-71	41	20	< 1	19	18	120	4.8	191	0	157	70
1ON3W17aba	60	8-17-71	28	10	< 1	86	24	19	3.8	265	0	217	97
1ON3W18adb	90	8-17-71	24	10	< 1	75	25	23	3.3	329	0	270	40
1ON3W19acc	23	8-18-71	21	10	10	77	22	15	2.1	272	0	223	51
1ON3W24cbd	60	8-16-71	22	10	< 1	30	6.7	12	2.9	104	0	85	48
1ON4W15dbb	38	8-18-71	32	10	< 1	98	66	83	6.8	235	0	193	370
1ON4W23bab	60	8-18-71	24	940	1,500	32	7.6	17	2.3	139	0	114	40
11N3W21dcc	23	8-17-71	31	50	650	63	21	24	12	298	0	244	47
11N3W30dad	52	8-18-71	17	10	60	76	25	30	3.3	298	0	244	84
11N3W32cab	—	8-18-71	23	10	< 1	67	16	15	3.2	244	0	200	59
11N3W33dac	25	8-17-71	24	10	< 1	62	12	15	3.2	213	0	175	55
11N4W13ddd	85	8-18-71	13	10	< 1	94	30	40	2.9	257	0	211	150
Reservoirs													
1ON2W8caa	3800	8-16-71	19	20	< 1	30	7.8	14	3.3	100	14	105	24
11N2W19abc	3651	8-16-71	30	10	80	67	18	28	4.4	262	0	215	71

^{1/} Micrograms per liter.

^{2/} Includes nitrite.

Table 2.--Chemical analyses of water samples from 18 wells
and two reservoirs--Continued

(Concentrations in milligrams per liter except as indicated)

Chloride (Cl), dissolved	Fluoride (F), dissolved	Nitrate as N ₂ /	Phosphate, dissolved ortho as PO ₄	Phosphorus, dissolved ortho as P	Phosphorus as P, dissolved	Dissolved solids (sum of constituents)	Calcium, magnesium	Hardness as CaCO ₃	Noncarbonate	Percent sodium	Sodium-adsorption ratio	Specific conductance (micromhos/cm at 25°C)	pH	Temperature (°C)	Detergents (MBAS)
Wells															
2.1	0.3	1.5	0.12	0.04	0.09	264	170	26	16	0.5	386	7.7	20.5	<0.01	
6.8	.2	.93	.15	.05	.10	280	200	24	16	.6	418	7.6	15.5	<.01	
6.4	.2	.42	.06	.02	.05	308	220	19	17	.6	487	7.3	17.5	<.01	
5.5	.2	.24	.21	.07	.08	299	210	6	18	.6	478	7.4	19.0	<.01	
3.0	.3	1.5	.06	.02	.09	245	160	27	17	.5	364	7.5	15.0	<.01	
2.2	.4	.61	.06	.02	.07	205	120	19	21	.6	303	7.5	14.5	<.01	
120	.6	.36	.18	.06	.07	489	120	0	67	4.7	669	7.8	16.0	<.01	
28	.4	.53	.09	.03	.09	419	310	96	12	.5	630	7.5	15.5	<.01	
21	.2	.67	.09	.03	—	376	290	20	15	.6	605	7.6	—	—	
27	<.1	.11	.15	.05	.07	350	280	60	10	.4	568	7.5	11.0	<.01	
2.1	.5	.64	.12	.04	.10	178	100	17	20	.5	256	7.5	12.0	<.01	
110	.2	1.6	.03	.01	.05	889	520	320	26	1.6	1,290	7.5	16.0	<.01	
3.0	.3	.01	.77	.25	.26	198	110	0	24	.7	297	7.2	10.0	<.01	
12	.9	.14	1.2	.38	.43	360	240	0	17	.7	550	7.4	18.0	<.01	
13	<.1	1.5	.15	.05	.06	402	290	48	18	.8	625	7.4	12.0	<.01	
5.9	<.1	.69	.18	.06	.07	312	230	33	12	.4	483	7.2	13.5	<.01	
6.9	.3	.33	.06	.02	.07	285	200	30	14	.5	434	7.3	18.5	<.01	
46	<.1	2.7	.03	.01	.02	514	360	150	19	.9	802	7.5	15.5	<.01	
Reservoirs															
5.7	.7	.11	.09	.03	.07	168	110	2	22	.6	256	8.5	18.5	<.01	
12	.6	.04	1.4	.44	.52	362	240	26	20	.8	520	8.3	22.0	<.01	

Quality related to man's activities

Of the suite of samples collected for analyses for constituents indicative of man's activities, 64 were from private wells and 5 were from buried drains. Concentrations of all constituents in the samples analyzed were within recommended limits for drinking water. The analyses are presented in table 3; ranges and median values of the various constituents are as follows:

<u>Constituent</u>	<u>Range, mg/l</u>	<u>Median, mg/l</u>
Chloride, dissolved (as Cl)	1.4 - 92	9.4
Nitrate, dissolved (as N)	< .1 - 6.3	1.0
Nitrite, dissolved (as N)	< .01 - .01	< .01
Methylene blue active substance	< .01 - .02	< .01
Phosphorus, dissolved (as P)	.01 - .47	.06

Although septic-tank effluent is continuously added to the valley-fill deposits, concentrations of the constituents in the sampled ground water were relatively low. Three possible explanations of this are: 1) dilution in ground water, 2) concentration at shallow horizons in the aquifer, or 3) a combination of one and two.

Water-quality maps were prepared to show the areal distribution of nitrate and chloride (figs. 4 and 5). These maps are based on data from tables 2 and 3. If the results for samples from buried drains and the two reservoirs are excluded, nitrate ranges from less than 0.1 to 6.3 mg/l and has a median of 0.9 mg/l for 82 analyses; chloride ranges from 1.4 to 120 mg/l and has a median of 8.4 mg/l.

Table 3.--Chemical constituents that may be indicative of man's activities. Water samples from wells and drainage ditches

(Concentrations in milligrams per liter)

Location	Depth of well (feet)	Date of collection	Chloride (Cl), dissolved	Nitrite as N, dissolved	Nitrate as N, dissolved	Phosphorus as P, dissolved	Specific conductance (micromhos per cm at 25°C)	Temperature (°C)	Detergents (MBAS)
10N2W7baa	38	8-31-71	9.5	<0.01	1.9	0.07	398	17.0	<0.01
10N2W19aad	74	9-1-71	8.0	<.01	1.2	.09	390	14.5	<.01
10N2W29bcc	80	9-1-71	29	.01	1.8	.08	733	14.0	<.01
10N3W2bdd	40	8-31-71	3.9	<.01	2.7	.09	402	12.0	<.01
10N3W3cac	50	8-31-71	2.3	<.01	1.4	.08	372	13.5	<.01
10N3W6add	45	8-24-71	11	<.01	2.1	.02	467	--	<.01
10N3W6bcc	--	8-23-71	3.4	<.01	.1	.01	325	14.5	<.01
10N3W6caa	45	8-23-71	15	.01	.5	.01	552	18.5	<.01
10N3W6cdc	65	8-23-71	4.8	<.01	.4	.01	470	13.0	<.01
10N3W6dca	42	8-23-71	9.2	<.01	1.2	.02	477	15.0	<.01
10N3W7aaa	40	8-23-71	7.9	<.01	1.5	.02	488	13.0	<.01
10N3W7add2	40	8-24-71	10	<.01	.7	.02	507	14.0	<.01
10N3W7dbc	32	8-23-71	8.5	<.01	.2	.01	446	10.5	<.01
10N3W7ddc	65	8-24-71	26	<.01	1.9	.02	708	14.0	<.01
10N3W8adc	60	8-25-71	14	<.01	1.7	.05	612	13.5	<.01
10N3W8bba	60	8-24-71	7.1	<.01	1.1	.02	409	18.5	<.01
10N3W8cdd	52	8-24-71	19	<.01	1.8	.03	607	12.0	<.01
10N3W9dda	82	8-31-71	8.6	<.01	1.0	.07	401	11.5	<.01
10N3W11aaa	35	9-1-71	3.8	<.01	1.5	.08	361	12.5	<.01
10N3W11cca	40	8-31-71	1.8	.01	.5	.07	317	21.5	<.01
10N3W11daa	46	9-1-71	2.3	<.01	.6	.08	318	14.5	<.01
10N3W12aaa	35	8-31-71	7.8	<.01	.6	.07	315	15.5	<.01
10N3W13cdd	64	9-1-71	3.7	<.01	1.2	.06	299	15.0	<.01
10N3W14add	61	9-1-71	2.1	<.01	.6	.08	291	15.5	<.01
10N3W18ada2	41	8-24-71	24	<.01	6.3	.01	636	9.5	<.01
10N3W18baa	52	8-23-71	25	<.01	1.3	.02	708	14.5	<.01
10N3W18ccc	53	8-23-71	51	<.01	1.4	.01	1,060	20.5	<.01
10N3W18cdd	86	8-23-71	16	<.01	.4	.02	649	20.0	<.01
10N3W18dbb	40	8-23-71	11	<.01	.6	.01	528	15.5	<.01
10N3W18ddd	66	8-23-71	18	<.01	.6	.02	618	15.5	<.01
10N3W22bac	55	9-1-71	9.4	<.01	.2	.08	387	15.5	<.01
10N3W23bbb	40	9-1-71	1.4	<.01	.2	.07	235	12.0	<.01

Table 3.--Chemical constituents that may be indicative of man's activities. Water samples from wells and drainage ditches--Continued

(Concentrations in milligrams per liter)

Location	Depth of well (feet)	Date of collection	Chloride (Cl), dissolved	Nitrite as N, dissolved	Nitrate as N, dissolved	Phosphorus as P, dissolved	Specific conductance (micromhos per cm at 25°C)	Temperature (°C)	Detergents (MBAS)
10N3W25bbb	60	9-1-71	4.3	<0.01	0.9	0.08	410	18.5	<0.01
10N4W1aab	76	8-30-71	11	<.01	.7	.07	393	14.0	<.01
10N4W12dad	--	8-30-71	5.9	<.01	.3	.06	485	16.0	<.01
10N4W13cbb	35	8-30-71	3.7	<.01	.1	.06	275	11.0	<.01
10N4W14bba	18	8-30-71	5.9	<.01	.1	.06	687	13.5	<.01
10N4W15baa	--	8-30-71	18	<.01	.5	.06	794	22.5	<.01
10N4W23aad	79	8-30-71	5.1	.01	.3	.06	374	15.0	<.01
10N4W23bac2	38	8-30-71	3.3	<.01	.1	.06	294	12.0	<.01
11N2W31bcb	28	8-31-71	6.6	<.01	<.1	.06	415	27.0	<.01
11N3W18dcd	--	8-30-71	16	<.01	5.0	.07	645	20.0	<.01
11N3W19dbc	45	8-25-71	11	<.01	1.7	.07	598	13.5	<.01
11N3W20ddd	BD ^{1/}	11- -71	20	<.01	2.6	.13	704	7.0	<.01
11N3W29abb	--	8-25-71	32	<.01	2.6	.07	685	10.5	<.01
11N3W29bac	--	8-25-71	23	<.01	1.6	.05	607	11.0	<.01
11N3W29ccb	40	8-24-71	16	<.01	2.5	.05	621	15.0	<.01
11N3W30daa	10	11- -71	41	<.01	<.1	.47	1,880	9.0	.02
11N3W30dbd	57	8-24-71	17	<.01	1.5	.04	683	19.0	<.01
11N3W31ada	BD ^{1/}	11- -71	18	<.01	1.5	.07	647	7.0	<.01
11N3W31dbc	55	8-24-71	7.0	<.01	.8	.06	593	15.5	<.01
11N3W31dcc	--	8-23-71	8.3	<.01	1.0	.02	593	11.0	<.01
11N3W31dda2	54	9-1-71	7.2	<.01	1.0	.09	556	13.0	<.01
11N3W32aaa	54	8-25-71	7.1	<.01	.9	.05	451	14.0	<.01
11N3W32acc	BD ^{1/}	11- -71	12	<.01	2.0	.06	536	5.0	<.01
11N3W32bad	BD ^{1/}	11- -71	16	<.01	1.5	.06	751	11.0	<.01
11N3W32bad2	BD ^{1/}	11- -71	17	<.01	3.2	.06	614	9.0	<.01
11N3W32cac	40	8-24-71	7.2	<.01	.7	.08	474	12.0	<.01
11N3W32cbb	30	8-24-71	6.9	<.01	.9	.05	554	15.0	<.01
11N3W32ccd	40	8-24-71	8.1	<.01	1.6	.06	458	11.0	<.01
11N3W32dbb	38	8-25-71	6.0	<.01	.6	.07	463	--	<.01
11N3W33cdd	45	8-31-71	16	<.01	.3	.07	423	--	<.01
11N3W36ccd	45	8-31-71	3.0	<.01	1.0	.07	346	18.0	<.01
11N4W13ccc	93	8-25-71	17	<.01	.5	.07	882	10.0	<.01

^{1/} Buried drainage ditch

Table 3.--Chemical constituents that may be indicative of man's activities. Water samples from wells and drainage ditches--Continued

(Concentrations in milligrams per liter)

Location	Depth of well (feet)	Date of collection	Chloride (Cl), dissolved	Nitrite as N, dissolved	Nitrate as N, dissolved	Phosphorus as P, dissolved	Specific conductance (micromhos per cm at 25°C)	Temperature (°C)	Detergents (MBAS)
11N4W24daa	90	8-25-71	19	< 0.01	1.6	0.05	842	11.0	< 0.01
11N4W25baa	90	8-25-71	92	< .01	4.1	.01	683	13.0	< .01
11N4W25daa	60	8-25-71	19	< .01	.9	.04	511	15.5	< .01
11N4W25ddc	74	8-30-71	11	< .01	.9	.07	525	13.0	< .01
11N4W36baa	110	8-30-71	6.4	< .01	1.0	.09	379	14.0	< .01

Except for a few high values, the highest was 6.3 mg/l, the normal range of nitrate in the valley is less than 0.1 to 2.0 mg/l. The map (fig. 4) indicates that some areas in the valley have higher concentrations than other areas. The patterns of nitrate concentrations and the direction of ground-water flow (fig. 3) imply that the sources of nitrate are in the valley. Likely sources include septic-tank effluent, leachate from the landfill dump, nitrogen fertilizers, and animal wastes. Three areas of highest concentrations (centered near 10N3W17b, 10N3W5b, and 11N3W29c) coincide with more densely populated parts of the valley and could be mainly related to septic-tank effluent. The area of high concentrations centered near 10N3W17b could be related to septic-tank effluent, animal wastes, or to sewage, which was reported to have been used to float the gold dredge that operated at 10N3W18 during the 1950's. Also, this high concentration centered near 10N3W17b could be partly caused by leachate from the landfill dump (10N3W30ba). The leachate could move through the highly permeable tailings left by the gold dredge. Two other highs (centered near 10N2W7 and 10N3W2) located in agricultural parts of the valley might be related to nitrogen fertilizers. Lower concentrations along Tenmile and Prickly Pear Creeks and around the edges of the study area (recharge area) indicate that ground water moving into the valley tends to dilute nitrate concentrations and flush the nitrate down gradient.

The areas of greatest chloride concentrations (fig. 5) are directly north of Helena and centered in 11N3W29. Agricultural areas in the east-central part of the valley do not have the relatively high concentrations of chloride that they do of nitrate. This difference is probably because the only major source of chloride in the agricultural areas would be solution of the basin-fill deposits. In addition to solution of minerals, major sources of chloride include salt used on streets during the winter and septic-tank effluent. Areas of low chloride concentrations, particularly along Tenmile and Prickly Pear Creeks, probably indicate that recharge is low in chloride.